Fetal pulmonary artery Doppler's predictive usefulness in newborn respiratory distress syndrome

Mohamed Ali Abbas1, Tasem Ragaa Mayallo2

1Department of medical physiology, Damietta Faculty of medical, Al Azhar University, Egypt.
2Obstetrics and Gynecology Department, Ministry of Health, Damietta, Egypt.

ARTICLE INFO

Article history:
Received 25 May 2024
Accepted 27 Jun 2024
Published 30 Jun 2024

DOi: 10.35192/jjoas.v18i1.1848

*Corresponding author:
Department of medical physiology, Damietta Faculty of medical, Al Azhar University, Egypt.
Email: drmohamedali22@gmail.com

Keywords:
Doppler indices
pulmonary artery
neonatal respiratory

ABSTRACT

Background: The most common cause of respiratory distress in premature infants is newborn respiratory distress syndrome (RDS). When evaluating the pulmonary circulation of a growing foetus, Doppler velocimetry offers a quick and painless method. Lowering pulmonary surfactant is linked to RDS, which is a major cause of infant morbidity and death since the pulmonary system is the last organ system in the foetus to physiologically complete before extrauterine life.

Aim of the work: This study aims to determine if fetal main pulmonary artery (MPA) Doppler indices can predict neonatal RDS.

Methods: Pregnant patients of the Obstetrics and Gynecology Department at Damietta Specialized Hospital which comprised (100) pregnant patients. RDS (n = 11) and No-RDS (n = 89). At 1 and 5 minutes, the Apgar score and the newborn’s birth weight (NBW) were recorded. Clinical indications of respiratory distress, supplementary oxygen need of 0.4 or more for at least one day, and typical chest X-ray findings.

Results: Neonates with RDS have statistically significant lower acceleration time/ejection time ratio, peak systolic velocity (PSV), systolic/diastolic (S/D) and statistically significant higher pulsatility index (PI), RI than those without RDS. At cut off level of >0.785, resistance index (RI) had sensitivity of 100% and specificity of 100% for predicting RDS.

Conclusion: Predicting Fetal lung maturity and subsequent development of newborn RDS with high levels of specificity and sensitivity is possible thanks to Fetal pulmonary artery clues.

Introduction

Respiratory distress syndrome (RDS) is common cause of respiratory failure and mortality in newborns. Because more people are aware of RDS, which was formerly thought to be predominantly prevalent in preterm newborns, the syndrome is now more routinely detected in term neonates (1).

A significant contributor to newborn morbidity and death is the respiratory distress syndrome (RDS), which is linked to lowering pulmonary surfactant. The last organ system in a developing foetus that needs more uterine life to develop physiologically is the pulmonary system (2).

Evaluation of the Fetal lung development is one of the most critical goals of obstetrical care. Historically, the maturity of the developing Fetal lungs has been assessed via amniocentesis and the examination of the proteins and lipids that make up the amniotic fluid. Amniocentesis, on the other hand, is an invasive procedure that is only recommended for particular purposes, and these tests have a high sensitivity but a low specificity (3).

Throughout pregnancy, the pulmonary circulatory advances alongside the lungs. Here, the overall quantity of tissue from smooth muscles increases, the total quantity of pulmonary vessels rises and the vascular restriction of the pulmonary arteries somewhat diminishes. It ends up resulting in a constant increase in pulmonary blood flow (4).

Doppler velocimetry is a fast and painless technique for evaluating the Fetal pulmonary circulation. Numerous researchers have assessed Fetal blood flow in the left (or right) pulmonary artery and its lateral branches using Doppler velocimetry (5).

There exists a demonstrated correlation between the Fetal pulmonary artery acceleration time/ejection time ratio (Au/Ei) and increasing Fetal gestational age (GA) and Fetal lung maturity (FLM) tests in amniotic fluid (6).

This study sought to examine the likelihood to employ Doppler hints and the Fetal major pulmonary artery to prepare for the first development of a condition called neonatal respiratory distress syndrome (RDS).

Patients and methods

One hundred expectant mothers were attending Damietta Specialized Hospital Obstetrics & Gynecology Department between the first of June (2022) and the end of June (2023) participated in a prospective cohort study.

Inclusion criteria:
At (37–38) weeks gestation, the female gives birth to one baby.

Exclusion criteria included
serious structural anomaly or Fetal chromosomal disorders, Fetal advancement at or below the ninety percentile for Fetal age, as well as any health issues pertaining to the mother’s pregnancy, such as gestational diabetes and preeclampsia and antenatal corticosteroid administration.

Neonatal follow up:
We shall record the newborn’s birth weight (NBW) and their Apgar score (at 1 and 5 minutes). We shall search for these
results of the study protocol. The data was only be used for study, and d = margin of error for reliability is p = anticipated (\( \frac{Z^2 \cdot p^* \cdot (1-p)*}{d^2} \))

Where:
- \( Z \) = For the ninety-five percent confidence level, use 1.96.
- \( p \) = anticipated (4%) rate of respiratory distress in neonates.
- \( d \) = margin of error for reliability is 0.03

We increased the sample size to one hundred individuals in order to increase the power of the study and adjust for protocol mistakes with missing data.

Ethical consideration

An informed consent obtained from each patient, after full explanation of the study protocol. The data was only be used for study, and no information on the patient’s privacy was be disclosed, despite the patient’s right to withdraw (Confidentiality will be ensured).

Results

Regarding mother age, newborn sex, and labour, there is no statistically significant difference between neonates with respiratory distress syndrome (RDS) and those without RDS Table 1.

Regarding APGAR score at 1 minute and 5 minute times, and there is no statistically noteworthy difference between premature babies with RDS and those without RDS. Neonates with RDS had statistically considerably more NICU attendance and needed oxygen treatment than neonates without RDS. In comparison to neonates without RDS, the birth weight of neonates with RDS was statistically significantly lower. Regarding mother age, sex, and labour, there is no statistically noteworthy distinction between newborns with RDS and those without RDS Table 2.

Table 2. Comparison of APGAR score, need for oxygen therapy, gestational age and neonatal birth weight of the studied population

<table>
<thead>
<tr>
<th>RDS</th>
<th>No RDS</th>
<th>Independent student T test</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=11</td>
<td>N=89</td>
<td>t</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>APGAR</th>
<th>1 min</th>
<th>Range</th>
<th>6-7</th>
<th>6-7</th>
<th>-0.098</th>
<th>0.923</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>6.56 ± 0.50</td>
<td>6.55 ± 0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>7 (1)</td>
<td>7 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APGAR</td>
<td>5 min</td>
<td>Range</td>
<td>7-9</td>
<td>8-9</td>
<td>2.156</td>
<td>0.050</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>-----</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>8.18 ± 0.59</td>
<td>8.54 ± 0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>8 (1)</td>
<td>9 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Admis- sion for O2</th>
<th>tt</th>
<th>Range</th>
<th>1-7</th>
<th>8-10</th>
<th>11.107</th>
<th>&lt;0.0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>9.00 ± 1.00</td>
<td>3.17 ± 1.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neonatal birth weight</th>
<th>gm</th>
<th>Range</th>
<th>3479.29 ± 695.03</th>
<th>2751.18 ± 695.03</th>
<th>13.968</th>
<th>&lt;0.0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>450.85</td>
<td>38.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gestational age weeks</th>
<th>Range</th>
<th>37-38</th>
<th>37-38</th>
<th>1.818</th>
<th>0.080</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>37.74 ± 0.44</td>
<td>37.09 ± 0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Neonates with RDS have statistically significant lower At/Et, PSV, S/D and statistically significant higher PI, RI than those without RDS Table 3.

Table 3. A comparison of the population under study’s Fetal pulmonary artery Doppler.

<table>
<thead>
<tr>
<th>RDS</th>
<th>No RDS</th>
<th>Student t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=11</td>
<td>N=89</td>
<td>t</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At/Et</th>
<th>Range</th>
<th>0.33 ± 0.35</th>
<th>0.34 ± 0.42</th>
<th>-17.326</th>
<th>&lt;0.0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SE</td>
<td>0.33 ± 0.01</td>
<td>0.39 ± 0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSV</td>
<td>Range</td>
<td>72.67 ± 73.37</td>
<td>75.54 ± 77.79</td>
<td>-30.481</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>73.62 ± 0.33</td>
<td>76.64 ± 0.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>Range</td>
<td>1.68 ± 2.23</td>
<td>2.48 ± 2.61</td>
<td>22.527</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean ± SE</td>
<td>2.52 ± 0.05</td>
<td>2.97 ± 0.41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RI</td>
<td>Range</td>
<td>0.80 ± 0.83</td>
<td>0.73 ± 0.77</td>
<td>18.508</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean ± SE</td>
<td>0.82 ± 0.01</td>
<td>0.75 ± 0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S/D</td>
<td>Range</td>
<td>6.13 ± 7.13</td>
<td>6.63 ± 7.35</td>
<td>1.771</td>
<td>0.098</td>
</tr>
<tr>
<td>Mean ± SE</td>
<td>6.94 ± 0.29</td>
<td>7.11 ± 0.37</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The relationships between At/Et, PSV, and S/D are statistically significantly inverse, although, RI and the length of oxygen therapy had a statistically significant positive interaction Table 4.

Table 4. Relationship between Fetal pulmonary artery Doppler measurements and oxygen therapy duration.

<table>
<thead>
<tr>
<th>The duration of oxygen therapy</th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBF</td>
<td>0.152</td>
<td>0.132</td>
</tr>
<tr>
<td>At/Et</td>
<td>0.443</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PSV</td>
<td>0.519</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PI</td>
<td>0.085</td>
<td>0.403</td>
</tr>
<tr>
<td>RI</td>
<td>0.432</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>S/D</td>
<td>0.578</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

At/Er had sensitivity of 94.4% and specificity of 90.9% to estimate RDS at cut off level of 0.346, PSV had sensitivity of 100% and specificity of completely for predicting RDS at cut off level of 74.45, PI had sensitivity of completely and specificity of fully for predicting RDS at cut off level of >2.35, RI had sensitivity of 100% and specificity of 100% for predicting RDS at cut off Table 5.
Discussion

There is no statistically important distinction between neonates with and without RDS in terms of the mother’s age, the baby’s gender, or labour. Our results supported Khalil et al.’s study (8) finding that RDS is not significantly associated with maternal age or parity, as well as Alsheikh et al. (9) observation of similar rates of RDS in neonate.

This suggests that Appgar scores at 1 and 5 minutes may not be sufficient indicators for early identification of RDS in neonates. Our findings are congruent with that of Buke et al.’s study (10), which found no meaningful differences in the 5th minute APGAR scores between newborns with and without RDS. However, the 5min APGAR score in the research by Abdelhamid et al. (11) showed statistically significant variations between newborns with and those without RDS. In contrast, Eldeen et al. (12) observed that compared to healthy newborns, RDS neonates had substantially lower Appgar scores at 5 min, lower birth weights, and were all committed to neonatal ICU.

The current study revealed that neonates with RDS required oxygen treatment at higher rates than neonates without RDS, and that their time in the NICU was statistically substantially longer. A research by Keshuraj et al. (13), which indicated that neonatal intensive care unit (NICU) admission rates likewise displayed a significant pattern of distinction, with 100% hospitalisation necessary for RDS (+) newborns and only 33.2% for RDS (-) babies, supported our findings. In a manner similar to this, Khalil et al.’s study (8) revealed that the need for NICU hospitalisation differed extensively between the two groups. In addition, the Laban et al. study’s (14) analysis of the criteria for NICU admission disclosed statistically significant variations between the two groups. Less than a 24-hour monitoring time was enough for two of the RDS newborns.

In the present study, neonates with RDS had substantially smaller neonatal weights upon birth than those without RDS. There is no statistically important difference between neonates with RDS and those without it when considering of gestational age. In the research by Moeyt et al. (15), higher amniotic fluid index values, lower estimated fetal weights on ultrasound, lower mean birth weights, and noticeably lower GA at delivery were all seen for foetuses that had RDS. Li et al. (16) studied the data and found that the age of gestation, delivery gestational age, and baby birth weight of babies in the NRDS group were likewise substantially fewer than those in the non-NRDS group. The discrepancy may be due to a different sample size. A newborn’s condition called respiratory distress syndrome (RDS) can be predicted through the pulmonary arteries resistance index (PA -RI) and Fetal lung volume (FLV) (17).

In a study by Keshuraj et al. (13), The median MPA PI values of the RDS (+) group foetuses were found to be higher when they were statistically compared. Statistical analysis of the mean MPA RI values revealed that RDS (+) group newborns had higher values. In contrast to the RDS (-) group, PSV was significantly lower in RDS-positive fetuses. The S/D ratio did not show any discernible variations between the two groups’ results.

Also, PA and RI were significantly greater in RDS newborns than in non-RDS infants, according to Ta et al. (18). Both PSV and the At/Et ratio showed a significant difference between newborns with RDS and the control group. Relative to neonates without RDS, neonates with RDS had a substantially higher HD RI. Compared to newborns without RDS, neonates with RDS had significantly lower PSV and At/Et ratios.

Additionally, Alsheikh et al. (9) and Khalifa et al.’s study (19) found that MPA PI and RI values were substantially greater in RDS-affected foetuses than in control foetuses. In comparison to the previous result, MPA At/Et was considerably lower.

A research by Khalil et al. (8) complemented our findings, suggesting that the At/Et mean in MPA Doppler velocimetry was significantly lower in foetuses who subsequently had RDS than in those who did not. While utilising a gestational age-specific threshold reached of less than or equal to the fifth percentile, Guan et al.’s study (20) found that AT independently could predict RDS with a sensitivity of 78.6% and an accuracy of 89.7%. The AT/ET ratio could foresee RDS with a sensitivity and specificity of 71.4% and 93.1%, respectively.

The cutoff value of 0.305 for AT/Et provided an accuracy of 76.4% and a specificity of 91.6% for the prediction of neonatal RDS with an area under the curve of 0.899.

In Khalifa et al.’s study (19), the ideal MPA PI and RI thresholds were 2.33 cm/s and 0.89 cm/s, correspondingly. The probability of RDS in babies with an MPA PI 2.33 cm/s and or RI 0.89 cm/s was much lower, with diagnostic accuracy of 94.4% and 88.1%, respectively. AUC = 0.94 and 0.96, correspondingly, with a 0.001 meaningful level.

Eldeen et al.’s study (12) additionally discovered the acceptable value for the ROC curve evaluation to anticipate newborn RDS was 0.75, with PA-RI 82.95% specificity and 76.27% sensitivity, and a cutoff of 28 cm3 for Fetal lung volume for newborn RDS development, with 65.91% specificity and 72.88% sensitivity. Combining the two indices produced a more reliable and sensitive predictor with 83% accuracy, 100% sensitivity, 65.91% particulars, 66.3% positive predictive value, and 100% negative prediction value.

Conclusion

Our research led us to the conclusion that Fetal pulmonary artery indices had a high sensitivity and specificity for predicting Fetal lung maturity and, consequently, the emergence of neonatal RDS. Although the main pulmonary artery At/ET measurement distinguished significantly between foetuses who developed RDS and those who did not, it is advised to combine it with other measurements because when used alone, it exhibits lower specificity across the range of gestational ages.

Declaration of Competing Interest

Regarding this paper, the authors disclose no conflicts of interest.

Data sharing plans

Data are available from the corresponding author upon reasonable request.

Funding

The authors pledge that no money was received for this project.

Author contribution

Each author made an equal contribution to the study.

References


